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# APPLICATION OF PROCESS MODELING TOOLS TO SHIP DESIGN

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# Summary, up front

- **Navy warships are:**

- Complicated
- Highly integrated
- Multi-mission
- Designed by the Naval Sea Systems Command (NAVSEA)

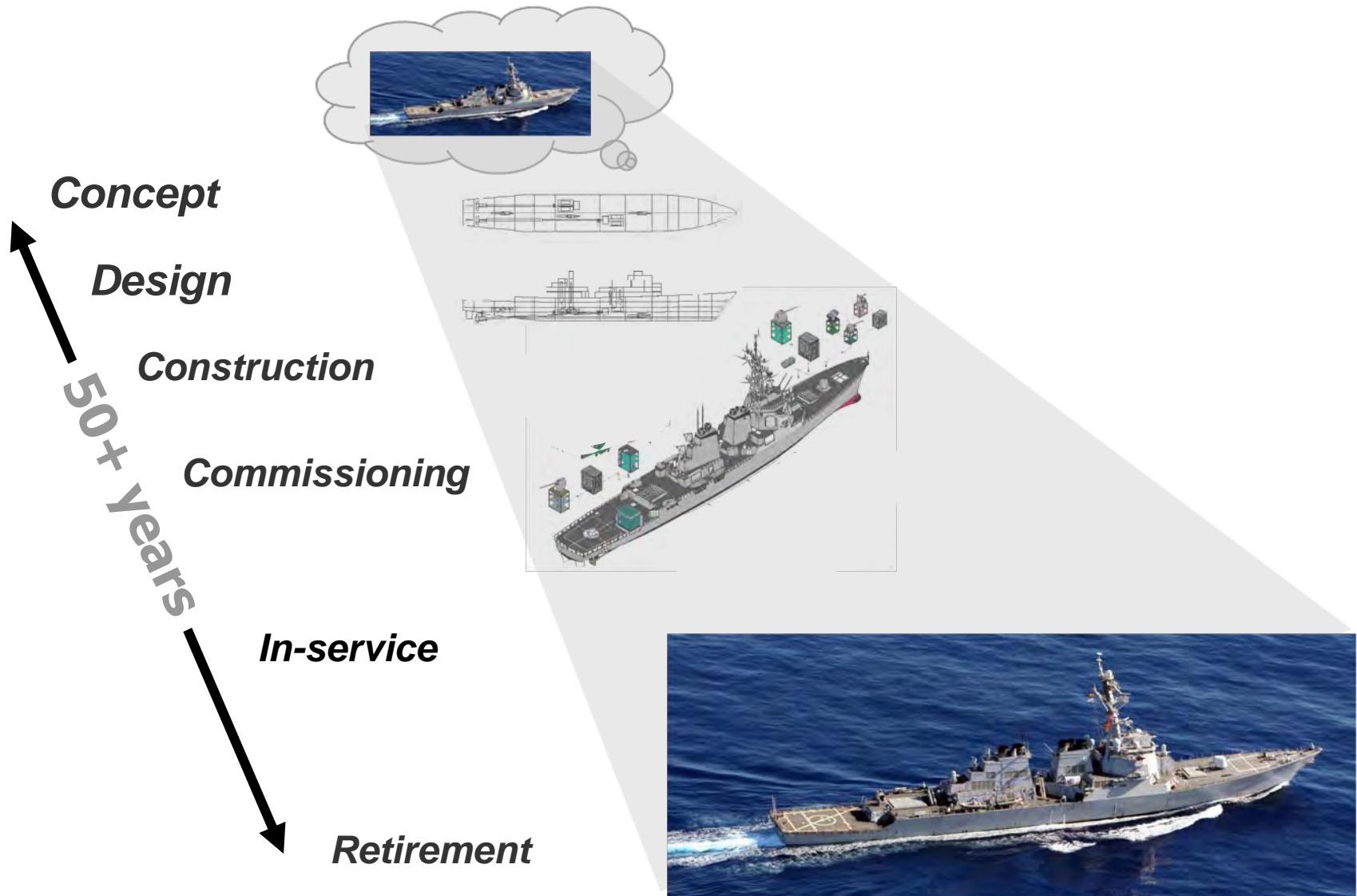
- **Naval ship design involves:**

- Large design teams
- Long design schedules
- Complicated acquisition procedures

- We are applying commercial process modeling techniques for:
  - Better Management
  - Process Improvement
  - Tool Evaluation
  - Training



# Warship Lifecycle



## Initial Motivation

- We needed a method for prioritizing software development.
- How should scarce resources for software be spent?
- Where would the highest return on investment be achieved?

We expected that a Ship Design Process Model would show:

- Where software was currently used;
  - Labor intensive activities;
  - Critical Paths; and
  - ROI.

# Typical Navy Surface Combatant DDG 51 Flight 1 Class Destroyer



**Length = 505 ft**

**Beam = 59 ft.**

**Displacement = 8,230 Ltons**

**Speed = 30+ knots**

**Crew = 276**

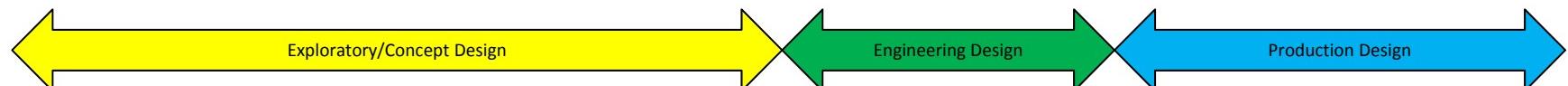
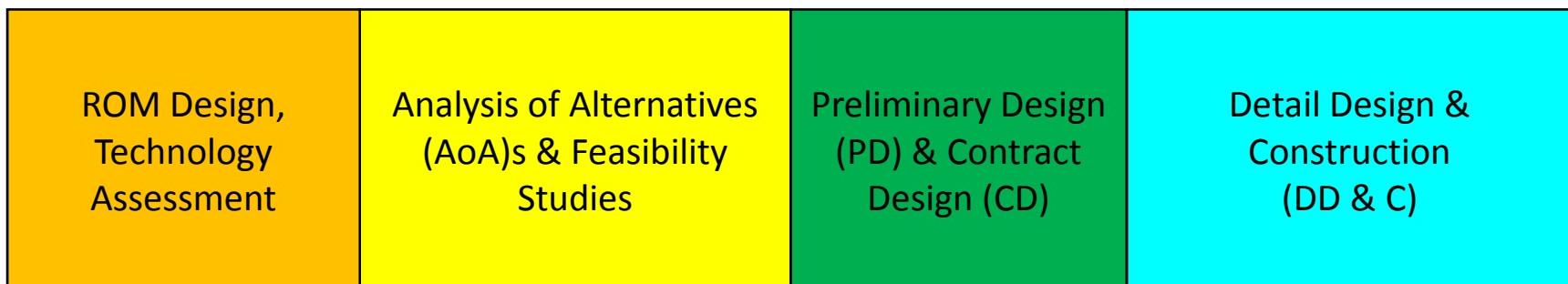
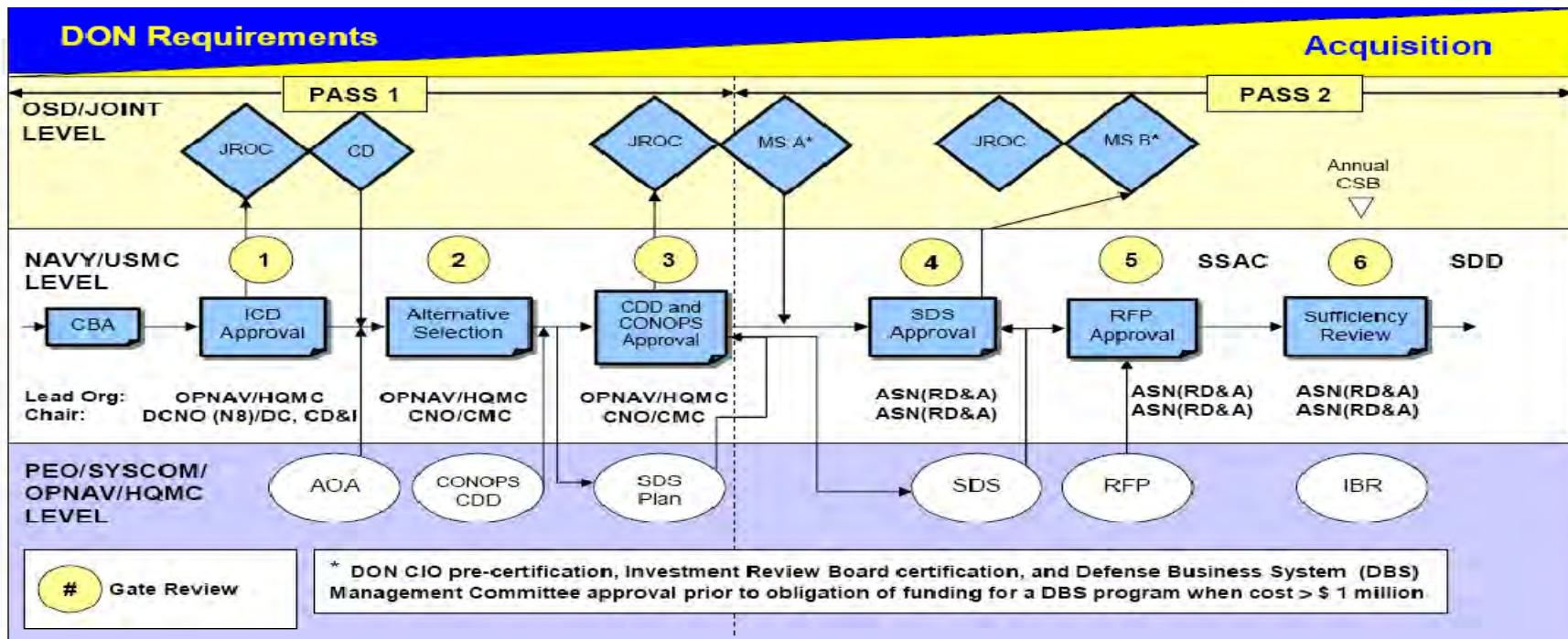
**Armament: Missiles,  
Torpedoes, Guns, Helicopters**

We modeled the design process for a conventional surface combatant because it was:

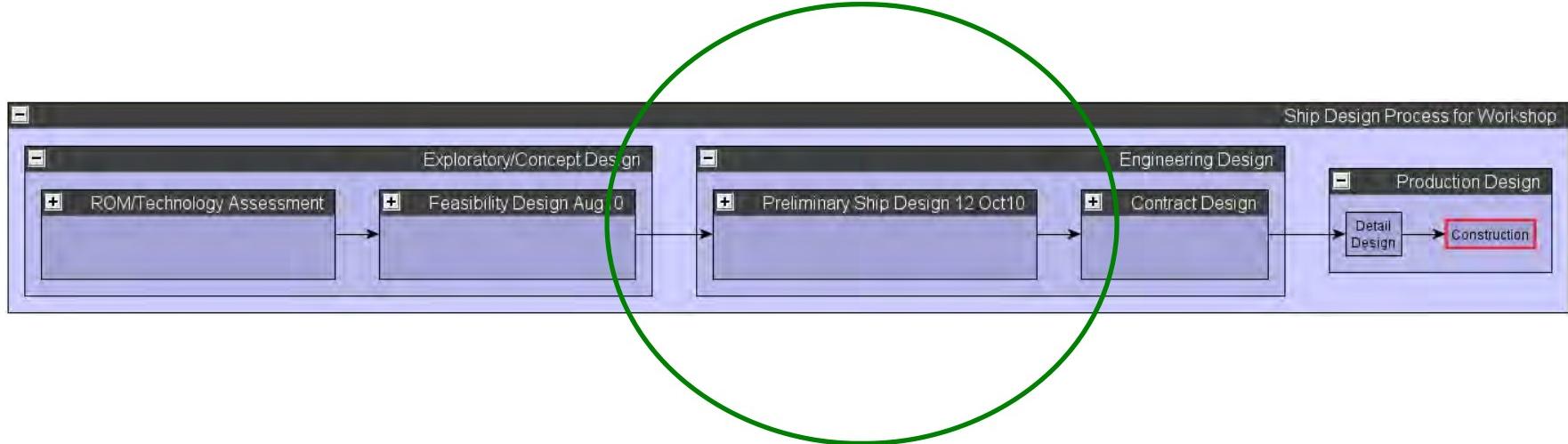
Sufficiently complex, but not as complex as an aircraft carrier;  
And it fit our organizational priorities.

<http://www.navy.mil/navydata/ships/destroyers/destroyers.asp>

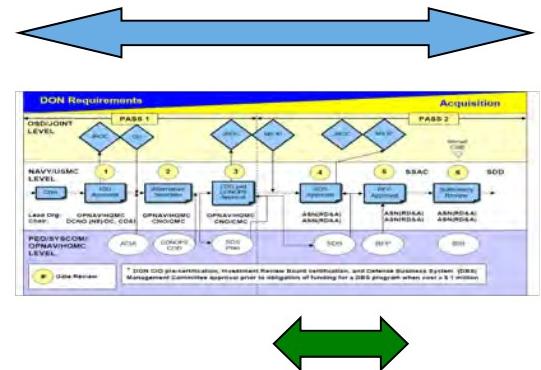
# Navy Ship Design and Acquisition Process



# An Integrated Model for the Entire Ship Design Process

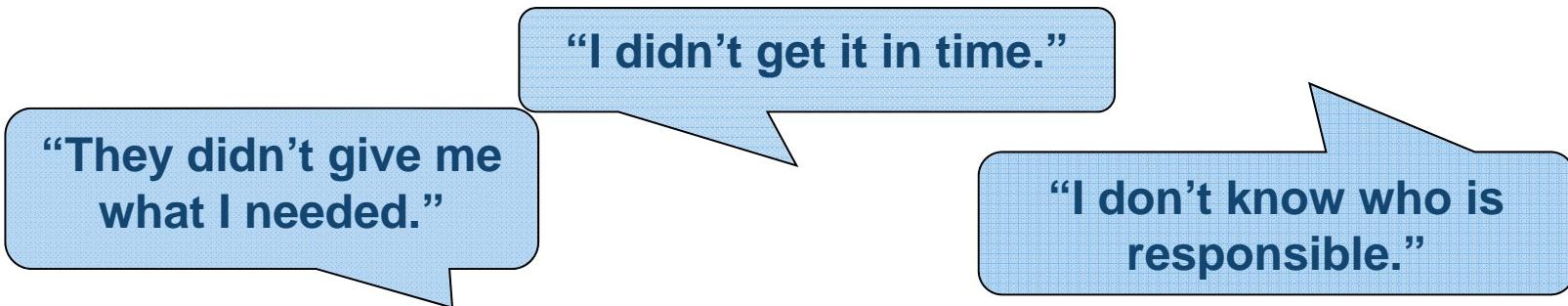


- We built a process model that could show all phases
- Initial efforts focused on Preliminary Design
  - Large number of participants
  - Many inter-related activities
  - High return on investment for improvements



# Interactions at all levels

- **Exchanges of information occur:**
  - Within Disciplines
  - Between Disciplines in the NAVSEA Organization
  - Between NAVSEA and NAVSEA Warfare Centers
  - With Contractors providing support at any level
- **Exchanges of information become more complex when organizations are under separate leadership.**
- **Dependencies between Activities = Implied Commitments**
- **Timeliness and Quality matter**



A process model defines commitments, enabling effective management.

# Our Process Modeling Objective

- We set out to evaluate and prioritize new software development.
- We needed:
  - Consistent understanding of where tools were used
  - Means for determining ROI
- Developing a process model supported these objectives, and more . . .
- Our objectives expanded:



# Varied Understanding of Process

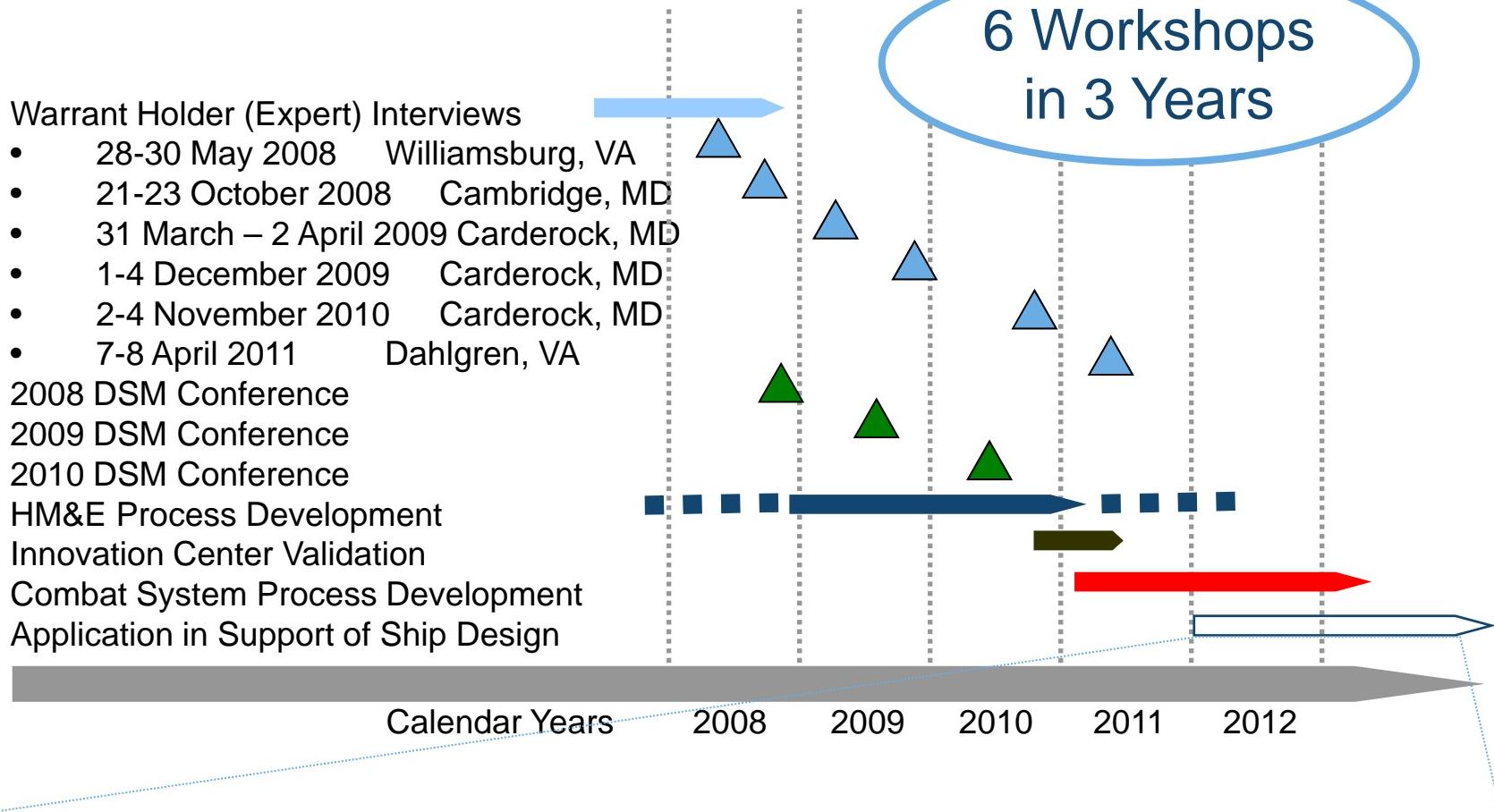
- We interviewed experts in specific technical areas.
- Some experts were not good at explaining their processes.
- If you cannot explain your process, how can you:
  - Discuss your role on the design team
  - Ensure you meet your commitments
  - Improve your process
  - Teach others about your process

?

We conducted semi-annual workshops to bring experts together.



# Workshop Timeframe



Discussing use of model in support of funded ship design projects.

Goal: Build Process Modeling Practice Based on Successful Application.

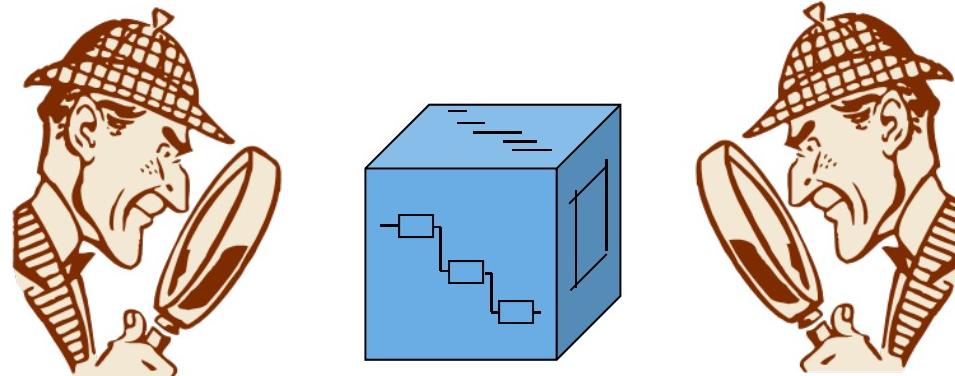
# Design Structure Matrix Methods

- We used Design Structure Matrix methods to capture process definition.
  - For info on DSM, see:  
<http://www.dsmweb.org/>
  - Workshop breakout sessions:
    - Experts brought together
    - Process activities identified; no need to worry about order
    - Dependencies identified
    - DSM put activities in order
    - Identifies highly interrelated clusters
    - Experts modified activities until satisfied
    - Deliverables and other details identified for each dependency

\$root	Output Susceptibility System Assessment	22
Output Recoverability System Assessment	21	
Develop Reliability Growth Plan	20	
Report Vulnerability Results/Conclusions	19	
Make Recommendations for Survivability Changes	18	
Capture Uncertainty in Assessments	17	
Generate Cost Estimates (EXTERNAL)	16	
Conduct Risk Assessment	15	
Prepare Cost Estimate Sheets	14	
Perform Damage Stability	13	
Perform Vulnerability Assessment (Modeling)	12	
Evaluate Whipping	11	
Evaluate Holing	10	
Evaluate Shock	9	
Conduct Trade-Offs	8	
Add Design Detail where Required	7	
Input Hit Distribution (EXTERNAL)	6	
Define Vital Systems and Spaces	5	
Evaluate Prior Phase (AoA) Designs	4	
Provide Recoverability System Inputs (EXTERNAL)	3	
Provide Susceptibility System Inputs (EXTERNAL)	2	
Review and Interpret Requirements	1	
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# Different People – Different Preferences

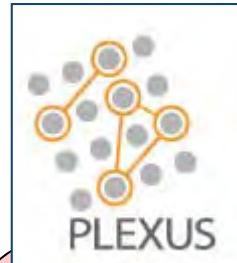
- **We need to view process data in multiple formats.**
  - DSM
  - GANTT Charts
  - “Boxes and Arrows” (IDEF)
  - Tabulated Data
- **The data must be consistent in all formats.**
- **We would like easy export to other applications**
  - Excel® files
  - CSV files
  - XML



# Integrated Process Model with Multiple Views & Interfaces



**Spreadsheets**



**Spreadsheet Software**

**Ship Design Process Database**



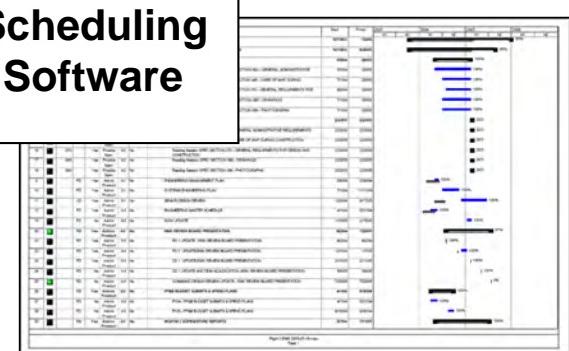
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Provide Recoverability System Inputs (EXTE			1																				
Evaluate Prior Phase (AeA) Designs	4	1	1	1	1																		
Define Vital Systems and Spaces	5	1	1	1	1																		
Input Hit Distribution (EXTERNAL)	6	1			1																		
Add Design Detail where Required	7	1	1	1	1																		
Conduct Trade-Offs	8	4	4	4	4																		
Evaluate Shock	9	1	1	1	1	1	1	4															
Evaluate Holing	10	1		1	1	1	1	4															
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**DSM Tool**

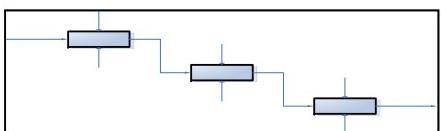
**DSM**



**Scheduling Software**



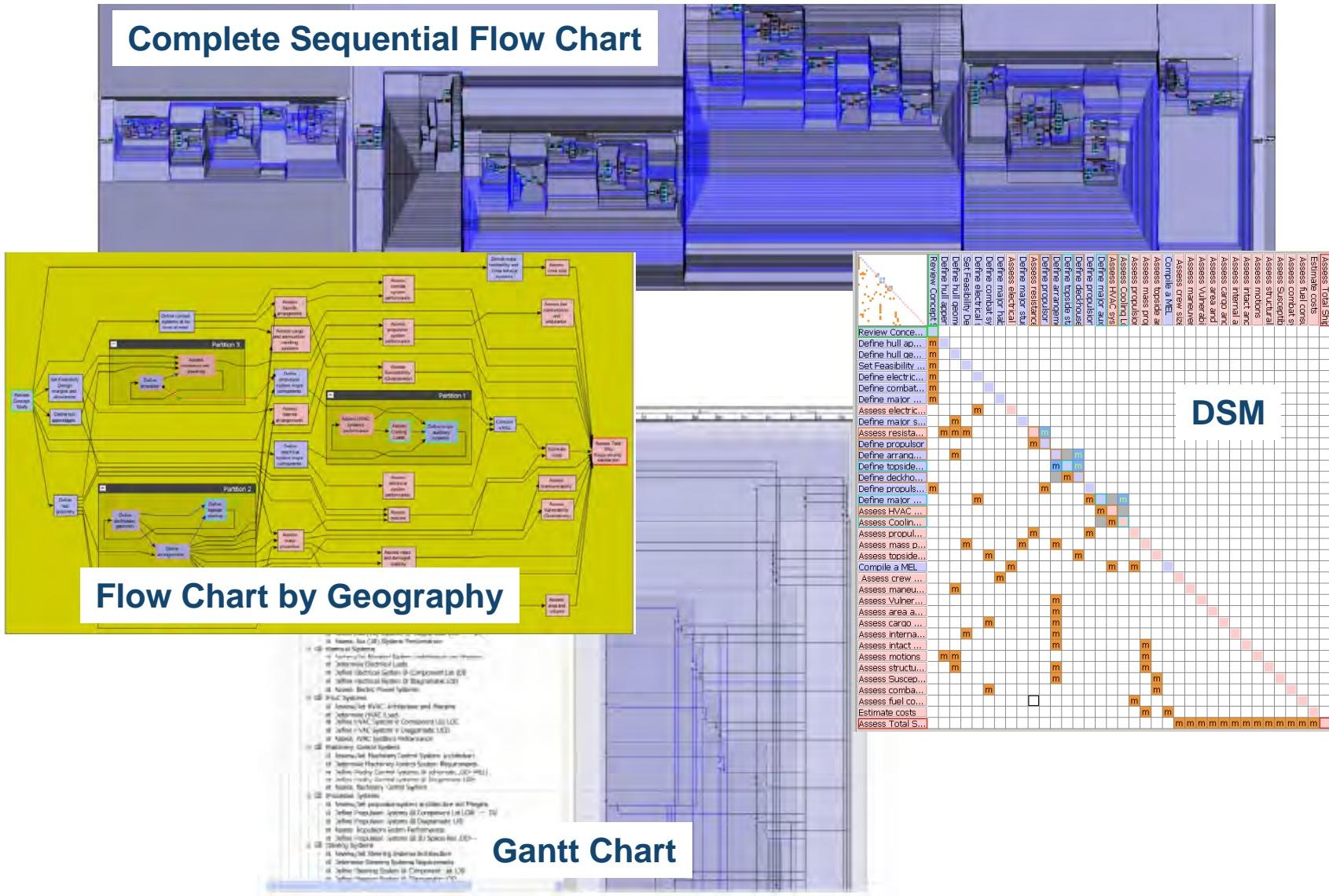
**Schema**



**IDEF Diagrams**

**Schedules**

# Different People – Different Preferences



# Multi-domain Views of Process

- **It is helpful to evaluate a project from multiple perspectives**
  - Process Order
  - Work Breakdown Structure
  - Organizational Responsibility
  - Geographic Location
  - Software Tools or Other Resource Dependency
- **The model being developed can produce output organized by domains of interest**
- **Examples:**
  - Division of Labor by Discipline
  - Critical Path
  - Organizational Distribution of Responsibility
  - Balance of effort by Worksites

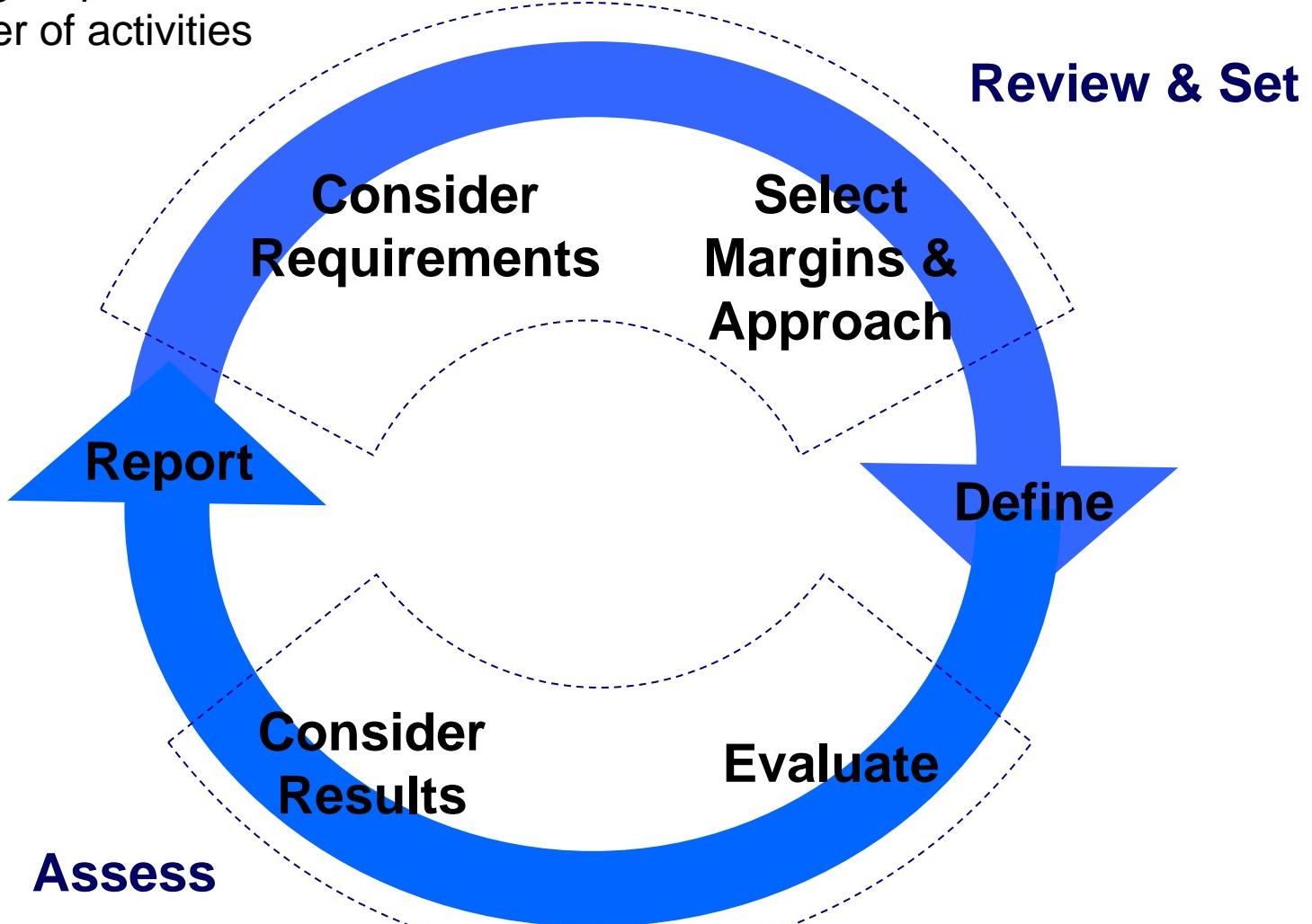
- Is your project collocated at the desired level?
- Is there a participant on the Critical Path that is remotely located?

# Complexity & Comprehension

- No need to model infinite detail
- We estimated we could comprehend about 1,000 objects.
- Our Preliminary Design Model is comprised of:
  - ~250 Activities
  - ~700 Dependencies
- In practice, this has worked out to be just about right.
- Keeping major blocks to this size is a good rule of thumb.
- Several blocks are modeled.
- Other conventions are also important:
  - Standard terminology or “Lexicon”
  - Consistent Terminology for Resources
  - Defined Start and Stop Activities (e.g. Design Reviews)

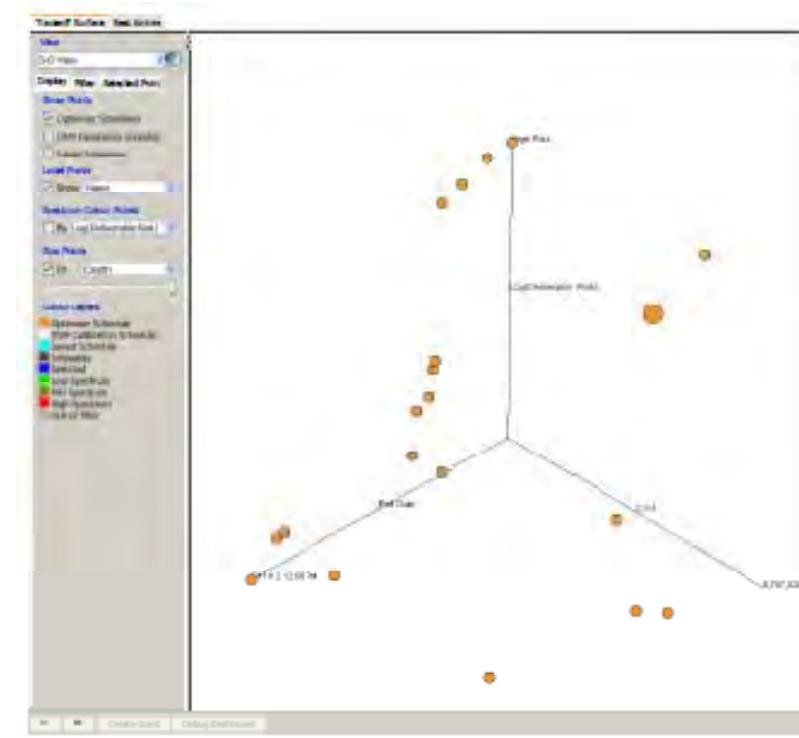
# Lexicon Hygiene – Standardized Nomenclature for Activities

Collapsing steps reduced  
the number of activities  
tracked.



# Process Simulation

- **The PLEXUS tool provides the benefit of process simulations.**
  - Explores trade-offs between Cost, Schedule, and Risk
  - Risk is reduced by iteration
- **We have only recently fully populated our model data and look forward to exploring the potential of process simulations.**



## Some Lessons Learned

- It is difficult to improve processes you have not defined.
- Even the best experts struggle to describe their processes.
- COTS tools provide needed capability.
- Use Appropriate Level of Detail.
- Work at a consistent level of detail.
- Use Standard Lexicon.
- A process model provides means to capture expert knowledge.
- A process model is a training tool.

## **Other Plans**

- 1. Expanding the scope of our model; working with other organizations to:**
  - Capture their process steps
  - Define process dependencies within the domain of the other agency
  - Define inter-dependencies with other agencies
- 2. Relating products to the high level DoD acquisition process**
- 3. Building a “practice”**
  - Not cost effective to train everyone in use of the model
  - Establishing small group of experts that assist in planning of new ship design projects, process improvement, software evaluation, or training
  - Naval Surface Warfare Center, Carderock Division (NSWCCD) is the home for this practice and trains young naval engineers.
- 4. Demonstrating effectiveness of model for new ship designs**
- 5. Applying risk and simulation capabilities**

# Summary

- **Complex engineering projects benefit from process models providing:**
  - A means for planning work
  - A way to evaluate alternative processes
  - ROI estimates for new software
  - Training of new employees.
- **Design Structure Matrix methods can be used to:**
  - Capture process definition in a facilitation setting
  - Provide insights into process complexity
  - Explore multi-domain relationships
  - Describe process activities and dependencies in a compact format
- **Commercial off-the-shelf process modeling software is available.**
- **Using standard nomenclature is recommended.**
- **The time and effort in process modeling is worthwhile.**

# APPLICATION OF PROCESS MODELING TOOLS TO SHIP DESIGN

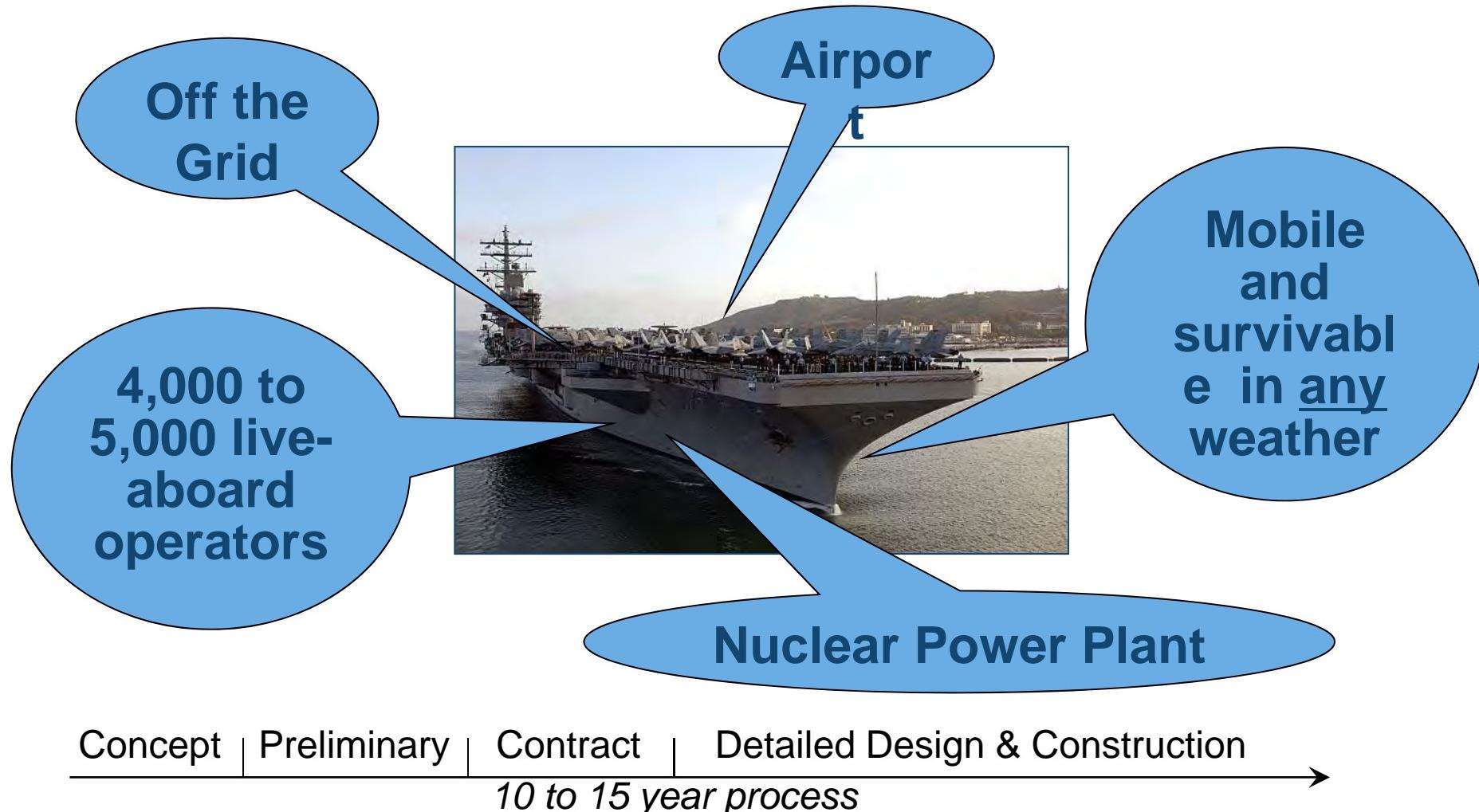
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Thank you very much.

dhelgers@csc.com



# Warship Complexity

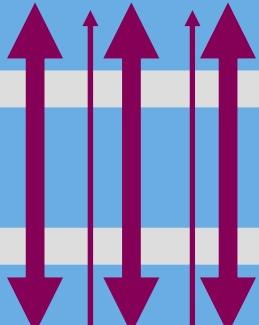


# Complex Process Interactions

## Mission Systems Design Development

*Many interactions at all levels.*

Aviation Systems

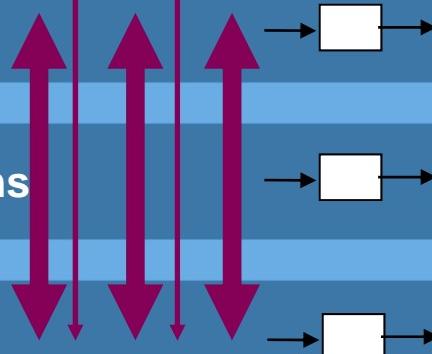


Weapons Systems

Combat Systems

## H,M, & E Design Development

Hull Systems



Mechanical Systems

Electrical Systems

# Process Database Methods

- **Process order is important.**
- **Organizational structure is also important.**
- **Other factors to track:**
  - Work breakdown structure
  - Geographic location
  - Software required
  - Resources
  - Schedule
- **Need to track large amounts of data**
- **Prepared schema for process database**

**Planned to create a tool to model our process;  
Found COTS software that met our needs.**

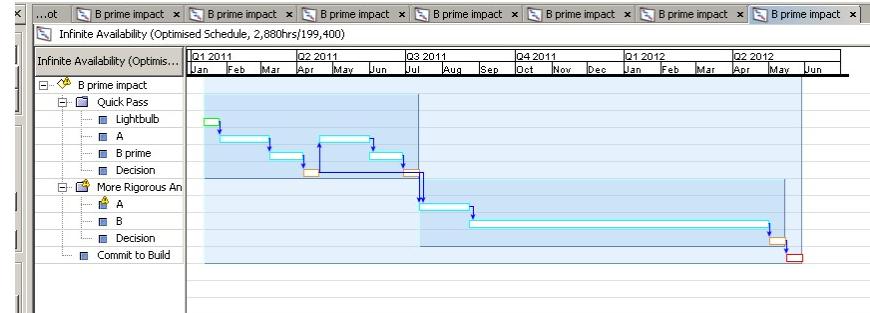
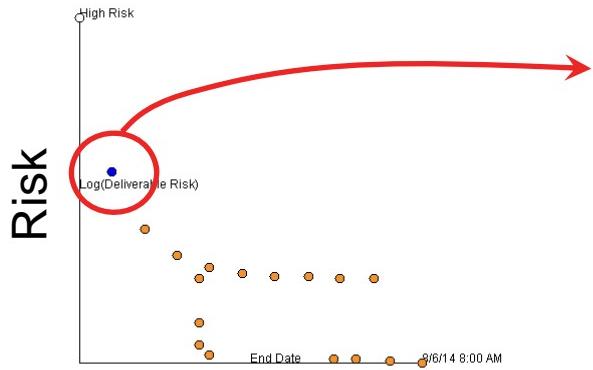
# Challenges

- Organizational Resistance
- Individual Resistance
- Willingness and Ability to Support Process Modeling
- Lack of Current Process Definition
- Experts Not Articulate about Process Steps
- Complexity
- Imprecise or Ambiguous Language
- Investment
  - Software Costs
  - Indirect Labor Costs
  - Schedule Availability & Priority

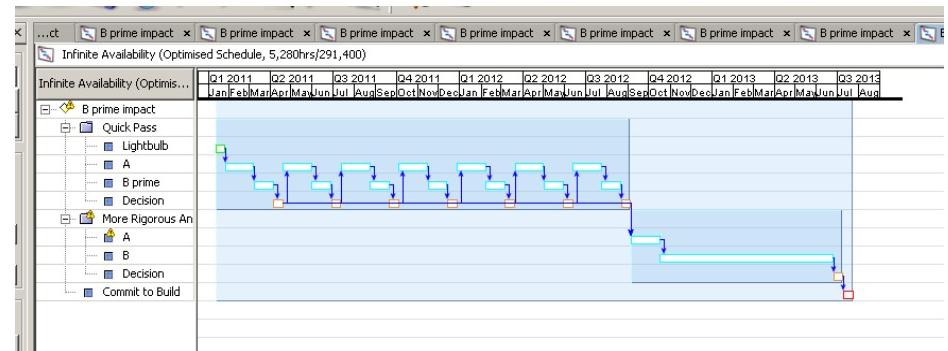
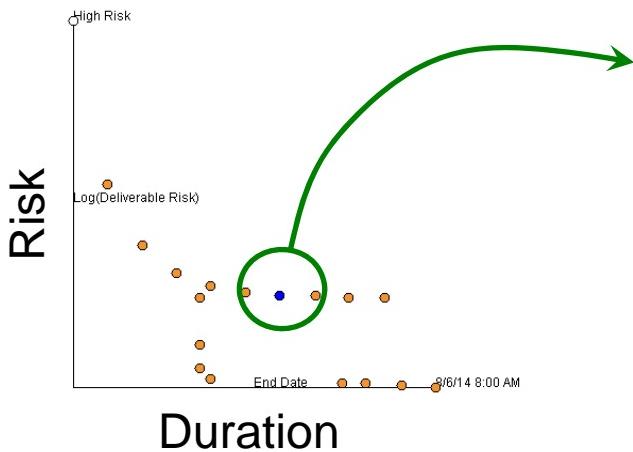
## Mitigation Strategy

- Management Briefings
- Management Priority
- Independent Group Facilitating Process Modeling
- Workshop Facilitation
- Workshop Facilitation Provides Lexicon and Encouragement
- Capable Modeling Tools
- Standard Definitions & Lexicon
- Briefing Key Managers to build Support and Line Up Funding for FY12 and Beyond
- Installing software on server to provide broader access.

# Risk Trade-Offs



Duration



Increased Iteration Decreases Risk Metric